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LONG TERM SCIENTIFIC STUDY ON
COMPUTER ASSISTED EXERCISE (CAX) TECHNOLOGY (LTSS/40)

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14. Abstract:
This paper gives an overview of the LTSS/40 and summarises the main results documented in the Final Report of this study. It shows the purpose and study procedure of an LTSS on the basis of LTSS/40. The definition of CAX and military operational needs have been derived from the existing Military Operational Requirements of NATO and nations taking the future new NATO tasks into account. The architecture of CAX reflects the functional, topological (organisational), and physical structure of CAX. Different topological options are shown and assessed. The relevant technologies are identified, their development is predicted, and recommendations regarding military R&D are given. The new aspect of using services instead of single technologies to build future CAX systems is introduced. The main conclusions of the study and the major recommendations conclude this paper.

LONG TERM SCIENTIFIC STUDY ON

COMPUTER ASSISTED EXERCISE (CAX) TECHNOLOGY

(LTSS/40)

# 1 INTRODUCTION

The new geo-political situation, new military tasks and types of operations, reduced force levels and the increased need to co-operate between different military services of different nations call for new training concepts and exercise support systems.

Large scale, field and command post exercises can no longer be conducted frequently due to environmental respect, reduced budgets, and lack of political acceptance.

Based on recent experiences with CAXs and new tasks for NATO forces that must be trained within budgetary and environmental restrictions, it has become apparent that advanced support calls for in-depth evaluation of relevant technologies.

Long Term Scientific Studies (LTSS) are conducted by the NATO Defence Research Group (DRG) Panel 1. The purpose of these studies is to provide a report on technological implications to military operations in the next 10 to 15 years and to give research planners recommendations.

The LTSS/40 on Computer Assisted Exercise Technology looks at technologies that can improve the possibilities to train commanders and their staff.

Based on the available definitions of CAX and Military Operational Requirements (MOR) required system capabilities are defined in this study which help to overcome present deficiencies. Functional, topological, and physical CAX architecture options are reviewed and compared.

The required system capabilities are the basis for the selection of relevant technologies, their evaluation and further development. Potential areas of technological developments are:

(1) Human Computer Interfaces;

(2) Command and Control Information Systems (CCIS) and Integration;

(3) Simulation Systems;

(4) Exercise Support Tools.

The development of technologies in support of these areas is examined and recommendations are derived on necessary Research and Development (R&D) to be initiated and sponsored by the military community.

More complex ADP-supported services instead of single technologies will play an increasing role for CAX designers and users in the future.

The study gives recommendations regarding NATO research activities in this field and shows military implications of the technological developments. This paper explains the conduct of the LTSS/40 and summarises the results as documented in the Final Report.

## 2 LONG TERM SCIENTIFIC STUDY - PURPOSE AND STUDY PROCEDURE

The NATO Armaments/Science/Research organisation is composed of three parts that are integrated under the North Atlantic Council.

Figure 1 shows these relationships:

(1) Non-Military Science is conducted under the Science Committee.

(2) NATO military requirements are developed under the guidance of the Military Committee. AGARD, SHAPE Technical Centre (STC) and SACLANT Centre (SACLANTCEN) are the organisations supporting these tasks.

(3) All aspects of military research, development and procurement are conducted under the Conference of National Armaments Directors (CNAD). The Defence Research Group (DRG) is a focal suborganisation. Panels are established under the DRG which conduct the work. Panel 1 is responsible for all Long Term Scientific Studies

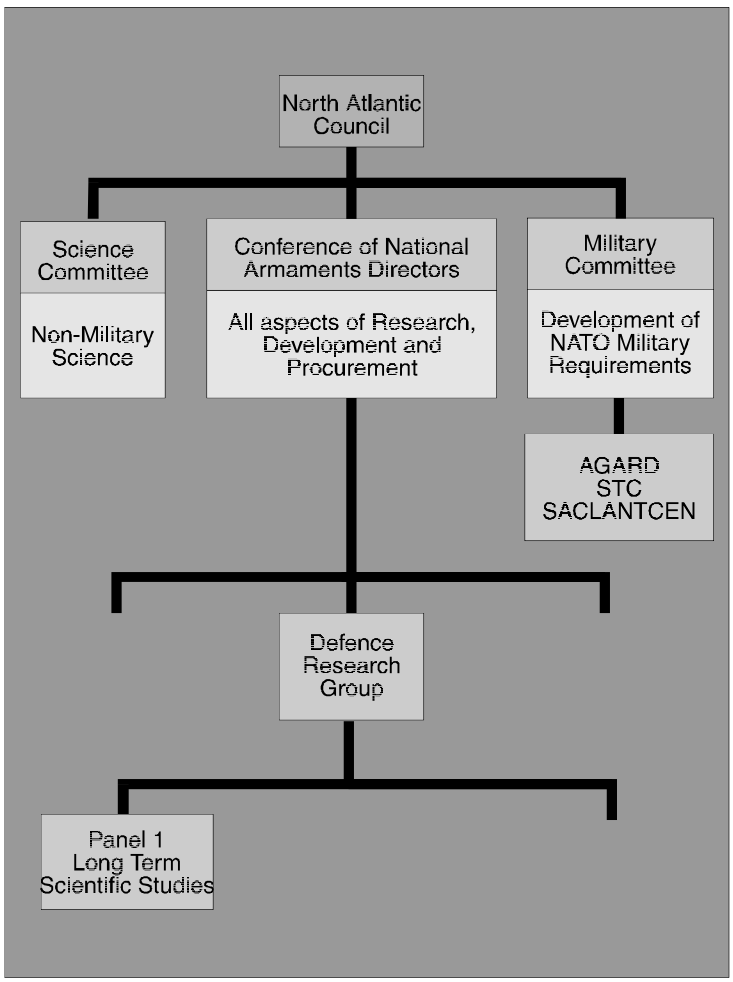


Figure 1: NATO Armaments/Science/Research Organisation

The purpose of Long Term Scientific Studies (LTSS) is to

(1) provide a report for the use by NATO and national authorities on technological implications to military operations in the next ten to fifteen years and to

(2) provide research planners with recommendations.

This means that technologies needed for a specific military task (e.g. for maritime operations or Computer Assisted Exercises) are identified and their development in the future is evaluated.

On the other hand, military requirements for the future are identified and the application of technological possibilities to meet these requirements is evaluated.

A comparison of these two views will identify areas for research and development (R&D) programs as a recommendation for research planners. Because of financial restrictions, such R&D programs should end up in co-operative efforts between NATO nations.

The time schedule of LTSS/40 shows the typical layout of an LTSS:

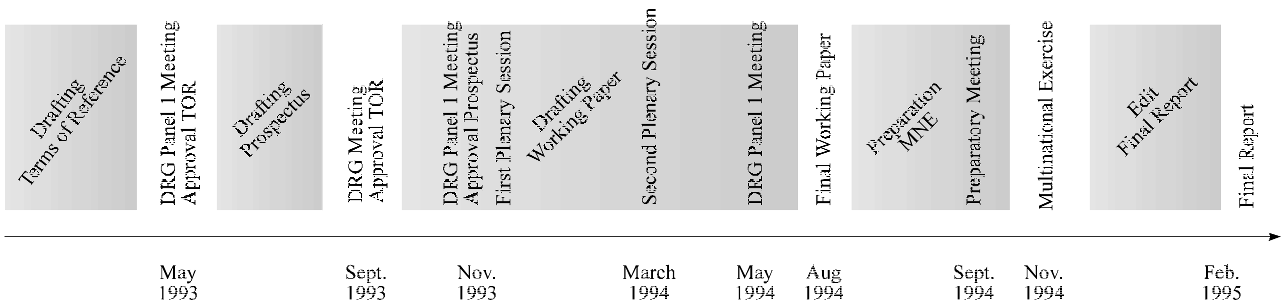


Figure 2: Time Schedule LTSS/40

(1) Executive Nation (for LTSS/40 Germany) drafts Terms of Reference (TOR).

(2) Panel 1 and DRG approves TOR.

(3) Study Director is nominated (Dr. Uwe K.J. Dompke and Günther Scheckeler as Deputy both from IABG, Ottobrunn).

(4) Executive Nation drafts Prospectus (lines out the Working Paper and gives a time schedule).

(5) Points of Contact (PoC) are nominated by participating nations.

(6) Executive Nation drafts Working Paper and discusses with the PoC in two plenary sessions (the basis of the discussions at the Multinational Exercise (MNE)). The final version is distributed to the PoC and the Defence Research Section.

(7) The Preparatory Meeting is intended to prepare the MNE.

(8) Scientific and operational experts from the different nations participate in the MNE and discuss in plenary sessions and Working Groups the spectrum of technologies related to CAX. Individuals do not represent their nations or agencies, but provide

knowledge and views only as experts in their area of technologies or in the military operational environment, respectively.

(9) The Final Report is drafted during the first week of the MNE and edited by the chairmen of the Working Groups, members of the Defence Research Section, the Study Director and the Deputy Study Director during the second week of the MNE.

(10) Panel 1 and DRG review the Final Report and forward it to the nations. National comments will be included in a Consolidated Final Report after one year. The LTSS report, will represent a consensus of expert opinions, rather than a position commonly agreed by nations.

The following NATO offices and nations are participating in the LTSS/40 on CAX and have nominated their Points of Contact:

| | | | |
|---|---|---|---|
| NACISA | SHAPE | SHAPE Technical Centre | SACLANT |
| Canada | Denmark | France | Germany |
| Greece | Italy | The Netherlands | Spain |
| United Kingdom | United States | | |

## 3 COMPUTER ASSISTED EXERCISE (CAX) - DEFINITION AND ARCHITECTURE

Throughout LTSS/40, "CAX" as a technical term is considered as part of an overall commanders and staff training and exercise programme. Any exercise in which automated tools are used can be considered a CAX.

Figure 3 shows a generic architecture of a system to support Computer Assisted Exercises.

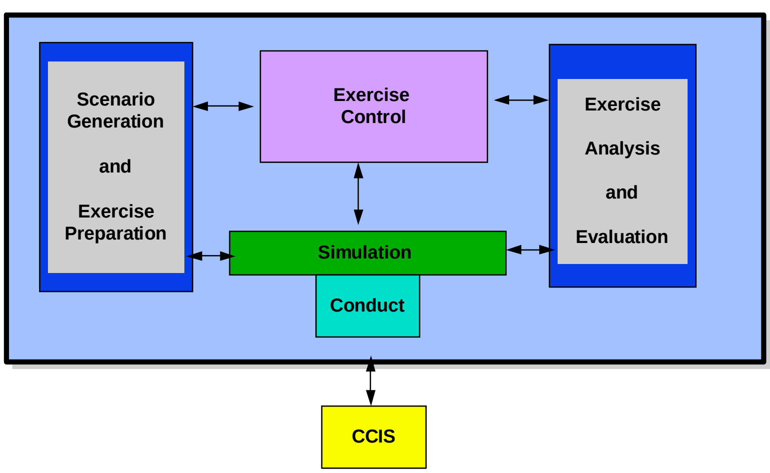


Figure 3: Functional CAX Architecture

The Directing Staff (DISTAFF) is responsible for the layout, preparation, conduction and analysis of the exercise.

Tools for exercise preparation support the definition of the scenario and the development and test of possible courses of actions.

The Tools for exercise analysis allow the evaluation of the data recorded during the exercise. They support the generation of reports and graphics as well as the selection of relevant data.

The exercising staff (or Primary Training Activity(PTA)) will use their normal operational environment. The underlying situation is generated by simulation models which are coupled with the operational CCIS by integration modules.

Response cells play subordinate and superior command levels as well as flanking commands. They need efficient decision support tools (DST) to limit the number of personnel needed to fulfil this task. The DST used for the response cells in CAX could be specific, e.g. highly automated systems that are not available in the operational system.

## 4 MILITARY OPERATIONAL NEEDS

The military operational needs set the requirements for CAX and form the basis to define systems that support Computer Assisted Exercises. They are the basis for the selection of relevant technologies, their evaluation and further development.

The current Military Operational Requirements (MOR) of the MNCs regarding CAX may be summarised as follows:

(1) The increasing need for commands to co-ordinate more closely in response to future crisis. Increased need for flexible use of forces and to conduct joint and combined operations. This leads to requirements for CAX systems which employ the CCIS and simulate a NATO-wide response to a regional crisis.

(2) The increasing constraints on live exercises due to environmental, political, and/or financial restrictions result in increased demand for synthetic exercises.

(3) The growing uncertainty of the nature of future crisis and the type and level of NATO response lead to a need for more "what-if" simulations of real-world events.

(4) The expanding need to train personnel from NATO, non-NATO countries and/or NGOs in procedures, concepts, etc. is best accomplished via CAXs.

It is expected that these requirements will remain valid and become even more important in the future.

Problem areas with the current level of support for CAX are described in the Final Report of the study. The needs are derived from this. They can be grouped into four major areas:

(1) Simulations/models:

    (a) Doctrine

    (b) Interface with CCIS

(c) Special Functions

(d) Standardisation and Interoperability

(e) Model/Simulation Speed

(2) Exercise planning, conduct and control, and analysis

(a) Reduction of Personnel in Response Cells (RCs)

(b) CAX Preparation Tools

(c) CAX Control

(d) (Online- and Post-) Exercise Analysis

(3) Capabilities for specific user requirements or special training events

(a) Interaction LIVEX/CAX

(b) Staff-Element Training

(c) Tutorials

(4) Human/Computer Interface

(a) Fidelity and Realism

(b) Representation of Objects and Functionality

(c) Customising

(d) Variable Resolution and Aggregation.

## 5 CAX ARCHITECTURE

The CAX Architecture is addressed from three perspectives:

The **Logical or Functional Perspective**. This view focuses on the logical or functional interrelationship of the CAX System Components and constitutes the **Functional Architecture of the CAX System**. The Functional CAX Architecture (s. Figure 3) is derived from the Military Operational Needs and it is not constrained by any System Topology or other CAX System Implementation considerations.

The **CAX System Physical Architecture** describes hardware and software components and their interrelationships for the CAX system. In future CCIS, as in other modern information systems, this physical architecture will not play the role it is playing today. New technologies available to implement functions on distributed systems and global data links will facilitate to concentrate on the functional and topological design of the systems.

The **CAX System Topology**. This view defines and evaluates available options for providing the CAX functionality. Six options are identified, each with a different degree of integration of CAX with CCIS and with a different degree of distribution of the CAX functionality itself. They differ in the organisational allocation of exercising environment components (exercise preparation, exercise conduct, exercise analysis and evaluation, and simulation).

(1) Fully Integrated CAX System Topology. The military organisation takes the responsibility to own, operate and maintain all exercise environment components. Furthermore, distribution is total as each headquarters is provided with their own capabilities.

(2) Fully Integrated Architecture with Technical HQ (s. Figure 4). In this cases the organisation has decided to specialise one headquarters in a certain function, e.g. the simulation function.

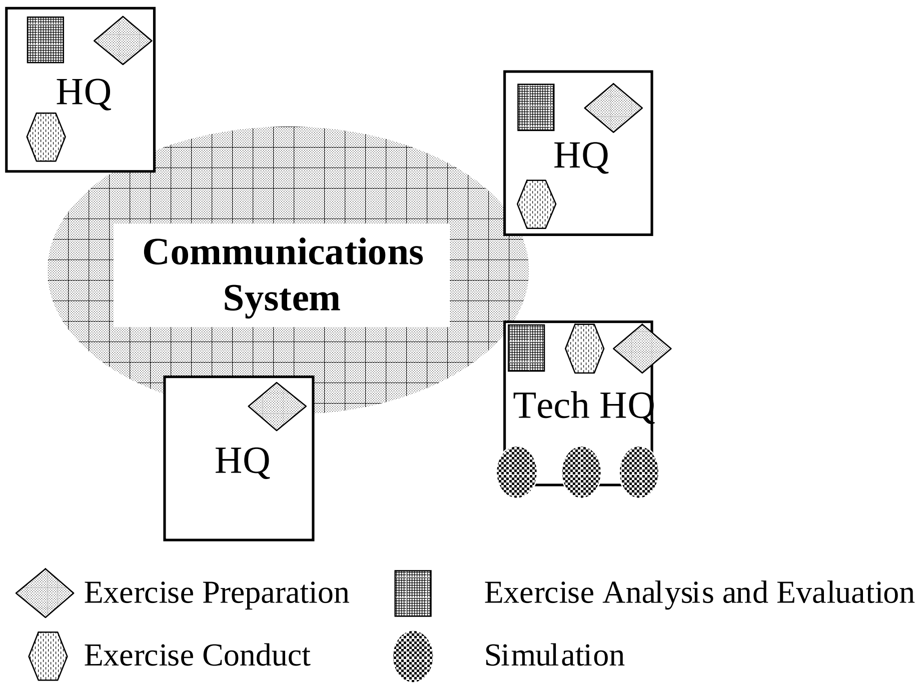


Figure 4: Fully Integrated Architecture with Technical HQ (Option 2)

(3) Integrated Architecture with External Organisation . A similar consideration as for option 2 may lead the organisation to leave the responsibility for certain functions with an external service organisation while retaining organisation-specific functions under its own control.

(4) Non-Integrated Option. For reasons of lack of specific expertise and capabilities, a non-integrated option can be selected. The organisation uses tools and capabilities provided by an external service provider.

(5) Distributed System with External Service Providers. In order to increase the diversity of services, and to bring market competition factors into play, option 5 can be considered which varies from option 4 in the number and diversity of service

providers. Within this option exercises may be supported by multiple co-operating and complementary service providers. The service is therefore distributed.

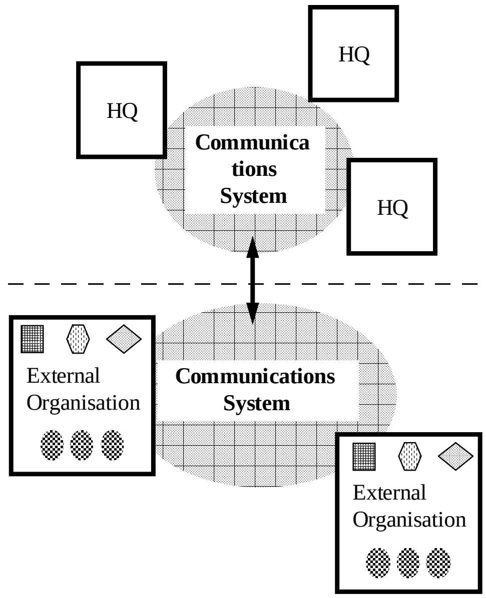


Figure 5: Distributed System with External Service Providers (Option 5)

(6) Distributed System with External Providers and Technical HQ . Option 6 is a variation on options 2 and 5. Indeed, there is a need for exercise service providers to interface with the CCIS. The security implications of doing so are great. In a world of growing internetting and increasing anonymity of network users, military organisations may fear such an openness and security costs may become prohibitive. Therefore it may be interesting to integrate some functions in the organisation and specialise a headquarters in providing the buffer between the CCIS and the external service providers.

The table shown on the next page summarises the results of the assessment made by the expert group, of the six CAX distribution options described above. The + and - signs indicates advantages or disadvantages in a qualitative manner. 0 indicates a neutral situation.

**Architecture Options**

| | | | ① | ② | ③ | ④ | ⑤ |
|---|---|---|---|---|---|---|---|
| | Criteria | Integration | full | semi | semi | none | n |
| | | Service | none | none | partial | full;one | fu |
| 1. | Satisfaction of parties involved | | | | | | |
| | Preparation | | + | ++ | + | + | + |
| | Control | | + | ++ | o | o | - |
| | Trainees | | o | o | o | o | o |
| | Analysis | | + | ++ | + | + | + |
| | System ”owner” | | -- | - | o | ++ | + |
| | Summary of 1 | | (o) | (++) | (o) | (+) | ( |
| 2a) | Cost of Implementation | | -- | - | + | + | + |
| 2b) | Cost & Effort of Ops & Maint. | | -- | - | - | - | - |
| 3. | Security | | + | ++ | o | - | -- |
| 4. | Openness to Suppliers | | - | - | o | ++ | + |
| 5. | Operational Control | | + | ++ | o | - | - |
| 6. | Technological Trends | | - | - | o | + | + |
| 7. | Flexibility to diff. Applic./Req’ts. | | - | - | o | + | + |
| 8. | Redundancy/Reliability | | ++ | + | + | - | -- |
| | Total Summary | | (-) | (++) | o | (++) | ( |

Table 1: Assessment of Alternative CAX Organisational Distributions

# 6 RELEVANT TECHNOLOGIES

## 6.1 User Interfaces

User interfaces (or Human Computer Interfaces (HCI)) play a very important role in CAX systems. They often determine the success of exercises and have an important impact on the amount of time and personnel required to prepare, execute and analyse an exercise.

On the other hand, the quality of the user interfaces tends to somewhat bias the judgement of the military user on the quality of software behind the user interface (e.g. simulation models).

Computer technologies in the past have been used primarily to augment traditional ways of performing tasks (e.g., by transcribing data onto electronic media). Future HCI interfaces should permit completion of tasks in innovative ways, taking maximum advantage of the power of the technology in performing missions. Many efforts are underway to improve computer interfaces and will be commercially available. We should monitor these carefully and use the most promising advances to improve our military command, control, and CAX capabilities.

## 6.2 Communications and Information Systems (CIS) and Integration

In discussing technologies that are essential for an effective integration of CCIS and exercising environments, we have to distinguish between technologies that are expected to emerge from commercially-driven research and technologies that will require military funding to come to fruition.

Commercial technologies that should be monitored and applied are:

(1) Speech recognition, analysis and interpretation

(2) Speech generation

(3) Computer graphics and animation

(4) Computer generated video images

(5) Image capture and object sensing

(6) Standard application interfacing

(7) Optical character recognition.

The technologies that will require considerable military R&D possibly in co-operation with interested commercial sectors are:

(1) Integrated security

(2) Automated reasoning and behaviour simulation

(3) Automated translation of natural language

(4) Automated translation of data models

### 6.3 Simulation Systems

The following technology areas related to the development and use of simulation systems in support of CAX are important:

Technology areas related to networked simulation. Network protocols for the exchange of a broad range of information at various hierarchical levels.

(1) Network management Operating Systems.

(2) Network throughput, including e.g. data compression techniques.

(3) Network security.

Technology areas related to modelling.

(1) Modelling of human factors, $C^3I$ and dynamic environment.

(2) Modelling of Crisis Management aspects, including joint/combined operations, strategic deployment, multiple forces, political-military interface, civil-military interface, Host Nation Support, low-intensity conflicts and escalation/de-escalation.

(3) Integrated hierarchical variable resolution modelling.

(4) Model parameterisation and customising, techniques to easily plug in/plug out alternative modules.

(5) Tools and techniques for Computer Generated Forces.

Technology areas related to development and maintenance.

(1) Simulation Operating Systems, offering services such as Geographic Information Services, Object Oriented Modelling and Data services, Configuration Management Services and Testbed Services.

(2) Advanced simulation development environment.

(3) Open standards.

(4) Validation & verification methods and techniques.

Military R&D should concentrate on following technology areas:

Networked simulation. The size and complexity of interaction of military networked simulation is quite unique, and military R&D will remain largely responsible for the developments in this area. Research will focus on convergence of networked protocols and network management services.

Object Oriented Design and Modelling (OOD/OOM). A considerable amount of modelling effort is needed to come to a common representation of objects and processes that play a role in military simulation. This effort is needed in order to gain a meaningful interoperability of models and to be able to share data and basic software modules and services. OOD/OOM must enforce a consistent view of the objects and processes at multiple levels of resolution and also account for non-conventional types of military operations.

Computer Generated Forces. In conjunction with industry and universities, military R&D must support the development and application of AI and decision support techniques for the implementation of automated or semi-automated forces that are able to represent human behaviour, with emphasis on the decision making process. In relation with this, effort should be put in understanding and modelling of human factors and C3I aspects.

Simulation Operating Systems and advanced simulation development environments. The effective and efficient development and use of simulation models could be greatly enhanced if a number of common services and development tools and techniques were easily available in an integrated fashion though so-called Simulation Operating Systems and/or advanced simulation development environments. The main task for military R&D is to stimulate the development of the basic services and tools needed, to tune them for specific use in a military simulation environment and to integrate them in a consistent way, Some dedicated basic research effort is called for, for example in real-time geographic information systems.

Validation & verification. Sophisticated though a simulation model may seem, the ultimate applicability of the model needs to be assured through the process of validating and verifying the model. Although some civil quality assurance tools and techniques can come in hand, V&V of military simulation requires a dedicated approach, using 'V&V benchmark' services that offer calibration facilities for the tuning of models.

### 6.4 Exercise Support Tools

Exercise Support Tools are used for preparation, control, and analysis of exercises. These tasks have been and continue to be very time consuming and manpower intensive. New technology, like Artificial Intelligence, will help to develop adequate tools to support these tasks.

Consensus was reached that the highest priority technologies (Display and Output Technology, Advanced Database Technology, Selection and Discrimination Technology and Expert Systems) will probably be developed in the commercial sector. Defence research must focus on the application of these techniques instead of the techniques themselves.

Other technologies - e.g. machine learning and artificial intelligence which are vital for analysis and evaluation - will probably require additional military research effort.

## 7 SERVICES

The development of information technologies shows a general trend to move the system developer, integrator and end-user away from basic technologies to higher aggregated technologies, tools, and services.

CAX designers/implementors will draw in 10-15 years from a large stock of higher aggregated services offering a variety of products serving specified groups of basic tasks. These services will have been built on more basic technologies by others and will be commercial and governmental available. An example for such services are Geographic Information Systems (GIS).

The "art" of building CAX systems and CCIS systems will be to integrate these services into a system which fulfils the requirements. The requirements depend on training objectives that are derived from tasks (war tasks, crisis management, humanitarian aids).

A consequence of these developments is that basic technologies will play a decreasing role for the system designer/integrator; they may even not have to be known in detail.

Services available or to come are of increasing importance as building blocks for functionality and technical architecture of CAX systems and CCIS as opposed to the basic technologies. Figure 6.5.2 shows the technology layering for CAX systems in the future.

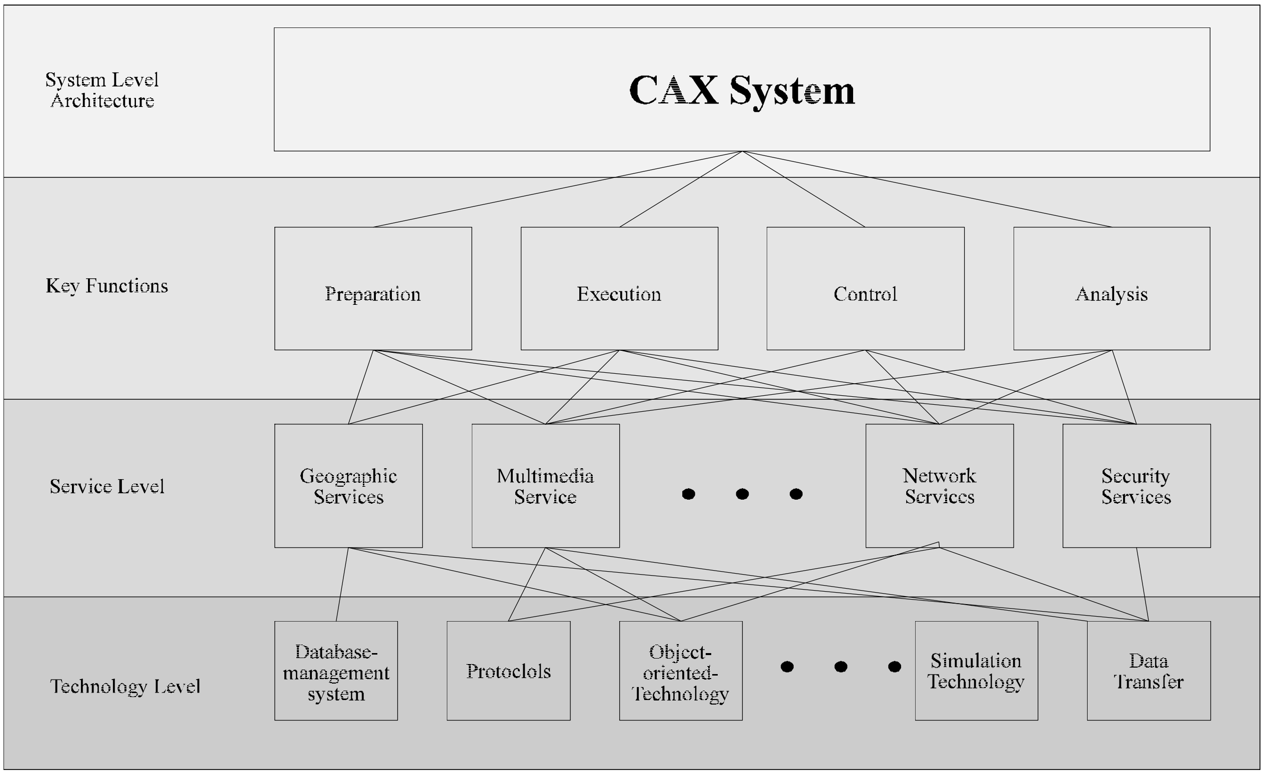


Figure 6: CAX Technology Layering

The following services will play a major role in the design and implementation of future CAX systems:

(1) Network Services and Wide Area Information Browsing

(2) Communications Systems Planning Services

(3) Security Services/Packages

(4) Libraries

(5) Archiving and Retrieval

(6) Multimedia

(7) Rapid Prototyping, Simulation Demonstration Environments

(8) Office Automation Environment

(9) Workflow Management Systems

(10) Planning and Management Support

(11) Automated Explanatory Briefings Associate

(12) Geographical Information Systems

(13) Simulation Operating Systems

## 8 MAIN CONCLUSIONS

Commercial technology will be the basis for most of the technologies needed for CAX. A "spin-in" is to be expected in the future. Commercial Of The Shelf solutions will be available to support many CAX tasks. The integration in and the adaptation to the military environment still remain as a challenge.

This "spin-in" will not only cover basic technologies to support CAX, but will also make use of externally provided services like geographical systems or e-mail. The use of these commercially provided services will have a heavy impact on military standards and operations. Beside this there still remains a need for selected specific military services that will not be covered by commercially available solutions (e.g. security).

The experience from past top down approaches to develop and implement information systems like CCIS and CAX support systems shows that this approach usually does not lead to acceptable solutions within time and budgets particularly in an area of emerging technologies. An evolutionary approach is mandatory, which is strongly recommended for the development and implementation of future CCIS and CAX support systems.

Users are becoming more familiar with and experienced in using information systems. This has consequences for the involvement of users in the development and implementation process. They will demand and recommend advanced technologies based on their own experience this way contributing to a high degree of final acceptance by the end user.

Interoperability will play a major role in the future. Standards and de-facto-standards are one means to achieve such interoperability between systems of different nations and suppliers. Civilian commercial standards will dominate all future information and communications systems. CAX systems should be based on these standards as far as possible to benefit from civilian markets investments (e.g. Open Systems).

The following six technologies have been evaluated to a **high priority** for improving future CAX systems and capabilities. The first three will be covered by commercial developments, so that the focus should be set on their military application;

(1) Multimedia;

(2) Office/Task Automation;

(3) Advanced Database Technology;

Defence oriented research and development should focus on:

(4) Networked Simulation;

(5) Computer Generated Forces;

(6) Integrated Security;

In addition, the following technologies have a **special potential** to improve future CAX systems:

(1) Intelligent Rooms

(2) Simulation Operating Systems and advanced simulation development environments

## 9 MAJOR RECOMMENDATIONS

Most advances in military computer technology will come from the adaptation of technologies of strong interest to civilian markets. To ensure that these markets focus on technologies that also satisfy military needs, NATO should act on the following recommendations:

(1) NATO provides proper forums for exposing industry to NATO's technology requirements (symposia and written requirements).

(2) NATO considers means of providing technology firms (software and hardware) with financial incentives (seed moneys) to conduct R&D and product development of systems most needed for 21st century CAX and CCIS.

The co-ordination of R&D-programs of the different NATO nations would help to reduce overall R&D cost. This co-ordination could be organised by using existing procedures and organisations in NATO (e.g. Defence Research Group). But also bilateral or multilateral research and development programmes which support the exercising of multinational forces will reduce cost, can be more efficient to achieve better training results.

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